

IN THE CLAIMS:

This listing of claims will replace all prior versions, and listings, of claims in the application. Currently amended claims are shown with additions underlined and deletions in ~~striketrough text~~ except double brackets may be placed before or after the deleted characters to show deletion of five or fewer characters.

1. (Currently Amended) A method of processing a substrate by chemical oxide removal (COR) comprising:

determining a desired state for the substrate, wherein the desired state comprises target critical dimension (CD) data ~~determined using at least one binning table;~~

receiving pre-process metrology data for the substrate, wherein the pre-process metrology data defines an input state for the substrate and comprises isolated CD data for at least one isolated feature and nested CD data for at least one nested feature ~~CD data determined using the at least one binning table;~~

determining a process recipe for performing a chemical oxide removal (COR) process and a post-heat treatment (PHT) process by:

comparing the input state with the desired state, wherein the isolated CD data is compared to the target CD data and the nested CD data ~~is~~are compared to the target CD data,

creating at least one binning table for a trim amount space extending between a lower boundary to establish a lower limit for trimming achievable by a series of pre-qualified control recipes and an upper boundary to establish an upper limit for trimming achievable by the series of pre-qualified control recipes, said at least one binning table divides said trim amount space into a plurality of bins, each of said plurality of bins has at least one of said pre-qualified control recipes

associated therewith that achieves an amount of trimming bounded by a lower trim amount boundary and an upper trim amount boundary.

correlating a first difference between the isolated CD data and the target CD data and a second difference between the nested CD data and the target CD data with a trim amount,

selecting a bin in said at least one binning table, wherein said trim amount is bounded by said lower trim amount boundary and said upper trim amount boundary for said bin, and

selecting one of said pre-qualified control recipes associated with said bin as said process recipe; and

processing the substrate to achieve the trim amount using the process recipe, the COR process including chemically treating the substrate by chemically altering ~~one or more~~ exposed Tunable Etch Resistant ARC (TERA) film surface layers of an oxide hard mask on the substrate and the PHT process includinga thermally treating the substrate to evaporate the chemically altered exposed TERA film surface layers of the oxide hard mask;

~~wherein a first delta is determined based on the difference between CD data for a first feature and first target CD data; a second delta is determined based on the difference between CD data for a second feature and second target CD data; and a TERA film trimming process is performed based on the difference between the first delta and the second delta and the chemically altered exposed TERA film surface layers are evaporated during the TERA film trimming process.~~

2. (Currently Amended) The method of processing a substrate as claimed in claim 1, the method further comprising:

receiving post-process metrology data for the substrate, wherein the post-process metrology data defines an output state and comprises ~~pre-qualified~~post-process CD data for a processed substrate;

determining if the desired state has been achieved by comparing said post-process CD data with said target CD data;

determining a new process recipe when the desired state has not been achieved; and  
transferring the substrate when the desired state has been achieved.

3. (Original) The method of processing a substrate as claimed in claim 1, wherein the pre-process metrology data comprises Optical Digital Profiling (ODP) data.

4. (Previously Presented) The method of processing a substrate as claimed in claim 2, wherein the post-process metrology data comprises Optical Digital Profiling (ODP) data.

5. (Previously Presented) The method of processing a substrate as claimed in claim 4, wherein the post-process metrology data comprises Scanning Electron Microscope (SEM) data.

6. (Previously Presented) The method of processing a substrate as claimed in claim 1, wherein the pre-process metrology data comprises at least one to-be-controlled CD and the process recipe is determined by comparing the at least one to-be-controlled CD to a target CD.

7. (Currently Amended) The method of processing a substrate as claimed in claim 6, wherein the at least one to-be-controlled CD is larger than the target CD ~~and the processing includes performing the TERA film trimming process.~~

8. (Currently Amended) The method of processing a substrate as claimed in claim 7, wherein said process recipe ~~the TERA film trimming process~~ comprises:

executing a chemical oxide removal (COR) process recipe for a COR module, wherein exposed ~~TERA film surface layers~~ of the oxide hard mask on the substrate are chemically treated using a process gas; ~~to form wherein a solid reaction product is formed~~ on at least one exposed ~~TERA film surface layer~~ of the oxide hard mask; and

executing a post heat treatment (PHT) process recipe for a PHT module ~~by executing comprises evaporating, wherein the solid reaction product is evaporated,~~ thereby trimming the chemically treated exposed ~~TERA film surface layers~~ of the oxide hard mask.

9. (Original) The method of processing a substrate as claimed in claim 8, further comprising: repeating the COR process recipe executing and the PHT process recipe executing until the at least one to-be-controlled CD is approximately equal to the target CD.

10. (Currently Amended) The method of processing a substrate as claimed in 9, further comprising:

receiving post-process metrology data, wherein the post-process metrology data defines an output state and comprises measured CD data for a processed substrate;

determining if a measured CD is approximately equal to a target CD;

repeating the COR process recipe executing and the PHT process recipe executing when the measured CD is not approximately equal to the target CD; and

stopping the execution steps when the measured CD is approximately equal to the target CD.

11. (Currently Amended) The method of processing a substrate as claimed in claim 7, ~~further comprising determining a trimming amount~~, wherein said process recipe the TERA film trimming process includes:

executing a chemical oxide removal (COR) process recipe for a COR module, wherein exposed surfaces on the substrate are chemically treated using a process gas, to form ~~wherein~~ a solid reaction product having a thickness approximately equal to the ~~trimming amount is formed~~ on at least one exposed surface; and

executing a post heat treatment (PHT) process recipe for a PHT module by evaporating the solid reaction product, thereby trimming at least one of the chemically treated exposed surfaces by the ~~trimming~~ amount.

12. (Currently Amended) The method of processing a substrate as claimed in claim 11, further comprising: examining a number of pre-qualified control recipes, wherein each control recipe has at least one pre-determined trim value; and selecting the pre-qualified control recipe having a pre-determined trim value approximately equal to the difference between ~~post-process~~ ~~pre-qualified~~ CD data and ~~pre-qualified~~ target CD data.

13. (Cancelled)

14. (Currently Amended) The method of processing a substrate as claimed in claim 1[[1]], further comprising: creating a lookup table containing a number of pre-qualified control recipes; and performing a table lookup to determine the process recipe.

15. (Previously Presented) The method of processing a substrate as claimed in claim 8, wherein the executing a COR process recipe comprises:

transferring the substrate into a module comprising a chemical treatment chamber;  
positioning the substrate on a temperature controlled substrate holder mounted within the chemical treatment chamber;

altering chamber pressure using a vacuum pumping system coupled to the chemical treatment chamber;

providing the process gas using a gas distribution system coupled to the chemical treatment chamber and configured to introduce at least one process gas into the chemical treatment chamber; and

controlling the COR module, the temperature controlled substrate holder, the vacuum pumping system, and the gas distribution system according to the process recipe.

16. (Previously Presented) The method of processing a substrate as claimed in claim 8, wherein the executing a PHT process recipe comprises:

transferring the substrate into a module comprising a thermal treatment chamber;  
positioning the substrate on a temperature controlled substrate holder mounted within the thermal treatment chamber;

altering the chamber temperature using a temperature controlled upper assembly coupled to thermal treatment chamber;

altering chamber pressure using a vacuum pumping system coupled to the thermal treatment chamber; and

controlling the PHT module, the vacuum pumping system, temperature control system, and the temperature controlled substrate holder according to the process recipe.

17. (Cancelled)

18. (Cancelled)

19. (Original) The method of processing a substrate as claimed in claim 15, wherein the process gas comprises a fluorine-containing gas and a nitrogen-containing gas.

20. (Original) The method of processing a substrate as claimed in claim 19, wherein the process gas comprises HF and NH<sub>3</sub>.

21. (Original) The method of processing a substrate as claimed in claim 8, wherein the process gas comprises a first gas and a second gas that are independently introduced to a processing space.

22. (Original) The method of processing a substrate as claimed in claim 15, wherein the temperature of the temperature controlled substrate holder in the chemical treatment chamber ranges from approximately 10° C. to approximately 50° C.

23. (Original) The method of processing a substrate as claimed in claim 15, wherein the temperature of the substrate mounted on the temperature controlled substrate

holder in the chemical treatment chamber ranges from approximately 10° C. to approximately 50° C.

24. (Original) The method of processing a substrate as claimed in claim 15, wherein the chemical treatment chamber pressure ranges from approximately 1 mTorr to approximately 100 mTorr.

25. (Previously Presented) The method of processing a substrate as claimed in claim 15, further comprising controlling the temperature of the process gas in the gas distribution system within a range from approximately 30° C. to approximately 100° C.

26. (Previously Presented) The method of processing a substrate as claimed in claim 15, further comprising controlling the temperature of a chemical treatment chamber wall within a range from approximately 30° C. to approximately 100° C.

27. (Original) The method of processing a substrate as claimed in claim 16, wherein the temperature of the temperature controlled substrate holder in the thermal treatment chamber ranges from approximately 10° C. to approximately 50° C.

28. (Original) The method of processing a substrate as claimed in claim 16, wherein the temperature of the substrate mounted on the temperature controlled substrate holder in the thermal treatment chamber ranges from approximately 10° C. to approximately 50° C.



29. (Original) The method of processing a substrate as claimed in claim 16, wherein the thermal treatment chamber pressure ranges from approximately 1 mTorr to approximately 100 mTorr.

30. (Original) The method of processing a substrate as claimed in claim 16, wherein the temperature of the thermal treatment chamber ranges from approximately 10° C. to approximately 50° C.

31. (Original) The method of processing a substrate as claimed in claim 16, further comprising: positioning the substrate at a first distance from the temperature controlled upper assembly during a first time; and positioning the substrate at a second distance from the temperature controlled upper assembly during a second time.

32. (Previously Presented) The method of processing a substrate as claimed in claim 16, further comprising controlling the temperature of a thermal treatment chamber wall within a range from approximately 30° C. to approximately 100° C.

33. (Cancelled)

34. (Currently Amended) The method of processing a substrate as claimed in claim 1, further comprising: performing a first trimming process based on the difference between the isolated CD data and the first target CD data; and performing a second trimming process based on the difference between the nested CD data and second target CD data.

35. (Currently Amended) The method of processing a substrate as claimed in claim 1, further comprising:

determining ~~a~~the first delta based on the difference between said isolated CD data for the at least one isolated~~first~~ feature and the target CD data;

determining ~~a~~the second delta based on the difference between said nested CD data for the at least one nested~~second~~ feature and ~~the~~pre-qualified target CD data; and

performing said~~a~~-trimming process recipe using said trim amount based on the difference between the first delta and the second delta.

36. (Currently Amended) The method of processing a substrate as claimed in claim 1, wherein the pre-process metrology data includes goodness-of-fit (GOF) data, and depth data.

37. (Previously Presented) The method of processing a substrate as claimed in claim 1, further comprising:

receiving post-process metrology data for the substrate, wherein the post-process metrology data defines an output state and comprises CD data for a processed substrate;

computing a predicted state for the substrate based on the process characteristics and a process model;

determining if the predicted state has been achieved by comparing the output state with the predicted state; and

computing a process model offset when the predicted state has not been achieved.

38. (Original) The method of processing a substrate as claimed in claim 1, wherein the process recipe is determined by executing a control strategy and a control plan.

39. (Original) The method of processing a substrate as claimed in claim 8, further comprising: transferring the substrate from the COR module to the PHT module.

40. (Currently Amended) A processing system for treating a substrate comprising:  
a processing subsystem comprising a chemical oxidation removal (COR) module for chemically altering exposed ~~Tunable Etch Resistant ARC (TERA) film~~ surface layers of an oxide hard mask on the substrate, a post heat treatment (PHT) module for thermally treating the chemically altered exposed ~~TERA film~~ surface layers of said oxide hard mask on the substrate, and an isolation assembly coupled between the PHT module and the COR module;

a first integrated metrology module (IMM) coupled to the processing subsystem for providing pre-process metrology data that determines an input state for the substrate, wherein the pre-process metrology data comprises isolated CD data for at least one isolated feature and nested CD data for at least one nested feature ~~CD data determined using the at least one binning table~~; and

a control device coupled to the processing subsystem and the first IMM, wherein the control device determines a process recipe for performing a chemical oxide removal (COR) process and a post-heat treatment (PHT) process to changing the substrate from an input state to a desired state by:

comparing the input state with the desired state, wherein the isolated CD data is compared to the target CD data and the nested CD data is compared to the target CD data,

creating at least one binning table for a trim amount space extending between a lower boundary to establish a lower limit for trimming achievable by a

series of pre-qualified control recipes and an upper boundary to establish an upper limit for trimming achievable by the series of pre-qualified control recipes, said at least one binning table divides said trim amount space into a plurality of bins, each of said plurality of bins has at least one of said pre-qualified control recipes associated therewith that achieves an amount of trimming bounded by a lower trim amount boundary and an upper trim amount boundary,

correlating a first difference between the isolated CD data and the target CD data and a second difference between the nested CD data and the target CD data with a trim amount,

selecting a bin in said at least one binning table, wherein said trim amount is bounded by said lower trim amount boundary and said upper trim amount boundary for said bin, and

selecting one of said pre-qualified control recipes associated with said bin as said process recipe; and

executes the process recipe to process the substrate to achieve the trim amount using the process recipe, the COR process including chemically treating the substrate in the COR module by chemically altering exposed surface layers of an oxide hard mask on the substrate and the PHT process including thermally treating the substrate in the PHT module to evaporate the chemically altered exposed surface layers of the oxide hard mask;  
~~wherein a first delta is determined based on the difference between CD data for a first feature and first target CD data; a second delta is determined based on the difference between CD data for a second feature and second target CD data; and a TERA film trimming process is performed based on the difference between the first delta and the second delta and the chemically altered exposed TERA film surface layers are evaporated during the TERA film trimming process.~~

41. (Original) The processing system for treating a substrate as claimed in claim 40, wherein the COR module further comprises a temperature controlled chemical treatment chamber, a temperature controlled substrate holder mounted within the chemical treatment chamber and configured to be substantially thermally insulated from the chemical treatment chamber, a vacuum pumping system coupled to the chemical treatment chamber, and a temperature controlled gas distribution system for introducing one or more process gases into the chemical treatment chamber.

42. (Original) The processing system for treating a substrate as claimed in claim 40, wherein the PHT module further comprises a temperature controlled thermal treatment chamber, a temperature controlled substrate holder mounted within the thermal treatment chamber and configured to be substantially thermally insulated from the thermal treatment chamber, and a vacuum pumping system coupled to the thermal treatment chamber.

43. (Previously Presented) The processing system for treating a substrate as claimed in claim 40, wherein the control device further comprises means for controlling at least one of a chemical treatment chamber temperature, a chemical treatment gas distribution system temperature, a chemical treatment substrate holder temperature, a chemical treatment substrate temperature, a chemical treatment processing pressure, a chemical treatment gas flow rate, a thermal treatment chamber temperature, a thermal treatment substrate holder temperature, a thermal treatment substrate temperature, and a thermal treatment processing pressure.

44. (Original) The processing system for treating a substrate as claimed in claim 40, wherein the isolation assembly comprises at least one of a thermal insulation assembly, a gate valve assembly, and a transfer system.

45. (Original) The processing system for treating a substrate as claimed in claim 41, wherein the temperature controlled chemical treatment chamber comprises a wall heating element.

46. (Original) The processing system for treating a substrate as claimed in claim 41, wherein the temperature controlled gas distribution system comprises at least one gas distribution plate, the gas distribution plate comprising one or more gas injection orifices.

47. (Original) The processing system for treating a substrate as claimed in claim 41, wherein the temperature controlled substrate holder in the chemical treatment chamber comprises at least one of an electrostatic clamping system, a back-side gas supply system, and one or more temperature control elements.

48. (Original) The processing system for treating a substrate as claimed in claim 41, wherein the temperature controlled substrate holder in the chemical treatment chamber includes one or more temperature control elements.

49. (Previously Presented) The processing system for treating a substrate as claimed in claim 41, wherein the gas distribution system comprises a first gas distribution plenum and a first gas distribution plate having a first array of one or more orifices and a second array of one or more orifices for coupling a first gas to a process space through the

first array of one or more orifices in the first gas distribution plate, and a second gas distribution plenum and a second gas distribution plate having passages therein for coupling a second gas to the process space through the passages in the second gas distribution plate and the second array of one or more orifices in the first gas distribution plate.

50. (Original) The processing system for treating a substrate as claimed in claim 49, wherein the first gas and the second gas are independently introduced to the process space.

51. (Original) The processing system for treating a substrate as claimed in claim 42, wherein the PHT module further comprises a substrate lifter assembly coupled to the thermal treatment chamber for vertically translating the substrate between a transfer plane and the substrate holder.

52. (Original) The processing system as recited in claim 40, wherein the processing subsystem is coupled to a manufacturing system.

53. (Previously Presented) The processing system as recited in claim 40, wherein the control device also determines if the desired state has been achieved.